



# **Comparison of Yoghurt Attributes Prepared from Tiger Nut (*Cyperus esculentus L.*) and Different forms of Cow Milk**

**Chidinma Adanna Okafor <sup>a\*</sup>, Ruth Asikiya Afunwa <sup>b</sup>,  
Moses Ojukwu <sup>c</sup>, Emmanuel Chisimdi Onyia <sup>a</sup>,  
and Oluebeube Eneh <sup>a</sup>**

<sup>a</sup> Department of Biological Sciences, Godfrey Okoye University, Enugu, Nigeria.

<sup>b</sup> Department of Pharmaceutical Microbiology and Biotechnology, Faculty of Pharmaceutical Sciences, Chukwuemeka Odumegwu Ojukwu University, Anambra State, Nigeria.

<sup>c</sup> Department of Food Science and Technology, Federal University of Technology Owerri, Nigeria.

## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author CAO designed research. Authors ECO, OE and CAO conducted research also provided reagents and materials. Author MO analyzed data. Authors CAO and RAA wrote the paper. Author CAO had primary responsibility for final content. All authors read and approved the final manuscript.*

## **Article Information**

DOI: <https://doi.org/10.9734/afsj/2024/v23i9740>

## **Open Peer Review History:**

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/122226>

**Original Research Article**

**Received: 23/06/2024**

**Accepted: 25/08/2024**

**Published: 29/08/2024**

\*Corresponding author: Email: [okaforca@gmail.com](mailto:okaforca@gmail.com);

**Cite as:** Okafor, Chidinma Adanna, Ruth Asikiya Afunwa, Moses Ojukwu, Emmanuel Chisimdi Onyia, and Oluebeube Eneh. 2024. "Comparison of Yoghurt Attributes Prepared from Tiger Nut (*Cyperus Esculentus L.*) and Different Forms of Cow Milk". Asian Food Science Journal 23 (9):11-18. <https://doi.org/10.9734/afsj/2024/v23i9740>.

## ABSTRACT

Yoghurt made from cow milk is popular due to its delicious taste and nutritional benefits. However, concerns about animal-based proteins have led to the evaluation of alternative options. This study examines the physicochemical, microbial and sensory characteristics of yoghurt made from tiger nut (*Cyperus esculentus* L.) milk compared to various forms of cow milk. Yoghurt was produced from tiger nut milk, full cream, fat-filled, and skim milk by fermenting the milk samples at 42 °C for 8 hours, using a starter culture. A commercial brand was used as a control. The samples were analyzed for physicochemical properties, microbial content and sensory attributes using a 9-point hedonic scale. The pH values ranged from 3.97 to 4.65 for tiger nut and skim milk yoghurts, respectively, while titratable acid ranged from 0.088 to 0.095 %. The control sample had the lowest total plate and lactic acid bacteria count values of  $1.361 \times 10^5$  and  $1.063 \times 10^5$  CFU/ml, while full cream milk had the highest values of  $2.123 \times 10^5$  and  $1.853 \times 10^5$  CFU/ml, respectively. The identified microorganisms were *Lactobacillus acidophilus*, *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Overall acceptability scores ranged from 6.88 to 7.63 for skim and full-cream yoghurt, with tiger nut yoghurt scoring 7.23. Therefore, tiger nut milk shows promise as a plant-based alternative for sustainable yoghurt production.

**Keywords:** Yoghurt; plant-based; milk; probiotics; microbial; sensory evaluation.

## 1. INTRODUCTION

The growing global population interested in healthy food options has led to a significant push to enhance food variety and nutrition. Meeting these interests through animal sources alone is far-fetched, raising the need for sustainable plant-based alternatives. Also, plant-based diets have fewer calories required to address the challenges associated with high blood pressure, obesity, lactose intolerance and ethics of vegetarian diets [1,2].

Yoghurt is a fermented milk beverage listed as one of the healthiest food products, resulting mainly from its nutritional composition and probiotic quality [3,4]. Probiotics are living microorganisms that, when consumed, have positive effects on the host, such as improved digestibility, enhancement of microflora, and immune stability [5].

Cow milk is known for its high protein content, including a complex mix of fats, minerals and vitamins [6,7]. Full cream milk still retains its natural fat content. Skim milk is produced by completely removing milkfat from full cream milk [8]. Fat-filled milk is formulated by blending skim milk with non-dairy fats such as vegetable oils [9]. Numerous industries presently utilize fat-filled milk in yoghurt production as a cost-effective alternative instead of full cream. However, the affordability of plant-based milk tends to be more promising [10].

Tiger nut (*Cyperus esculentus* L.) an underutilized nut, is chosen for its high levels of essential nutrients, health benefits, affordability

and availability [2,11,4]. Its milk content is high. However, few studies have compared tiger nut milk, especially with fat-filled milk for yoghurt. Therefore, this research aimed to compare the physicochemical, microbial and sensory attributes of yoghurt produced from tiger nuts and different forms of cow milk.

## 2. MATERIALS AND METHODS

The samples used for this research were Dano milk powder (full cream, skim and fat-filled), fresh tiger nut tubers, freeze-dried starter culture (yogourmet) and a commercially known brand of yoghurt to serve as the control. All were obtained from a local market in Enugu state and transported to the laboratory for analysis.

### 2.1 Sample Preparation

#### 2.1.1 Preparation of tiger nut milk

The method employed had slight modifications [11]. Fresh tiger nuts were sorted, washed and drained. Water (2 L) was added to 500g of tiger nut and placed in a water bath at 45 °C for 12 h, to enhance softening, milling and milk extraction. The hydrated nuts were drained and milled using a blender at 1800 rpm for 5 min. After that, distilled water (1 L) was added to form tiger nut mush. Then, strain through a cheesecloth, and the filtrate (tiger nut milk) was pasteurized for 15 min at 75 °C [2]. The milk was cooled to 45 °C for inoculation and fermentation.

#### 2.1.2 Preparation of cow milk

Full cream powdered cow milk (600 g) was dissolved in 1.5 L of distilled water and stirred

properly. It was pasteurized at 85 °C for 5 min and cooled to 45 °C for inoculation, followed by fermentation. This same procedure was used for skim and fat-filled milk powders [12].

### 2.1.3 Preparation of yoghurt the yoghurt

Each sample (1 L) of tiger nut, full cream, skim and fat-filled milk was immediately inoculated with 5g of a freeze-dried starter culture (yogourmet), in separate beakers. After inoculation, samples were tightly covered and placed in an incubator at 42 °C for 8 h to ferment. The fermented samples (Yoghurt) were refrigerated at 4 °C for further analysis [13].

## 2.2 Physiochemical Attributes of the Yoghurt Samples

### 2.2.1 Determination of pH values

The pH values of each sample were measured using a pH meter. The pH meter was standardized by testing the buffer solutions of known pH. This aimed to test the acidity level of the yoghurt samples [14].

### 2.2.2 Determination of titratable acidity (TA)

Each yoghurt sample (1g) was mixed with 10 ml of hot distilled water (90 °C) and titrated to a faint colour with 0.1N NaOH comprising 0.5% phenolphthalein as an indicator. The percentage of lactic acid produced by fermentation in the sample was determined as follows [14].

$$\text{Titre value} \times 0.09 \times 100 \%$$

(Where the Titre value is the Volume of yoghurt sample solution used; 0.09 is a conversion factor).

## 2.3 Microbial and Biochemical Determination

### 2.3.1 Determination of microbial count

Homogenized yoghurt samples (1 ml) each were aseptically transferred into a corresponding sterile test tube containing 9 ml of distilled water up to a four-fold serial dilution. Using the pour plate method, dilutions 2 and 4 were cultured on MRS and Nutrient Agar, the plates were incubated at 37 °C for 24h and the colonies were counted for bacteria load. All counts were expressed as CFU/ml. Pure cultures were obtained by sub-culturing on sterile fresh MRS and nutrient agar plates for Lactic acid bacteria

count and Total coliform count, respectively. The plates were incubated at 37°C for 24 h. The obtained pure culture was stored on agar slants and refrigerated at 4°C. Isolates were identified using morphological, biochemical and gram-staining tests [15,12].

### 2.3.2 Catalase test

The catalase test is used to distinguish microorganisms that can produce catalase enzymes. A clear, grease-free slide was treated with 3% hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>), and a small amount of each bacterial isolate was placed on the glass slide using a sterile inoculating loop, allowing for the isolate's bubbles to develop. Bubbles show catalase positive, while the absence means catalase negative [16].

### 2.3.3 Oxidase test

The ability of organisms to produce cytochrome oxidase enzymes is employed in oxidase tests. The oxidase reagent was freshly prepared into a 1% solution, and filter paper strips were immersed. The culture was scratched with the inoculating wire loop. Positive reactions are indicated by a vivid, deep-purple hue that appears within 5–10 seconds, while adverse reactions are indicated by a lack of colour [17].

### 2.3.4 Coagulase test

The coagulase test differentiates pathogenic from non-pathogenic test organisms through their ability to coagulate blood plasma. Two distinct grease-free slides each received a few drops of saline, and a loop of the bacterial isolates was emulsified on slides to create two suspensions. A sterile Pasteur pipette was used to collect a drop of human plasma, which was then gently mixed on the slides. The glass was checked for clumping after 5–10 minutes. The presence of clumping indicated coagulase-positive, while the absence showed coagulase-negative [14].

### 2.3.5 Gram staining

This test was employed to test the organisms microscopically and differentiate Gram-negative from Gram-positive using coloured stains. Smear was created, placed on a spotless glass slide, and stained for 30 seconds with crystal violet. The smear was then cleaned with distilled water. Gram's iodine was applied for 10 seconds, after which the smear was washed with tap water, decoloured with 95 % acetone alcohol, and dyed

with safranin for 30 seconds. The smear was then rinsed with tap water, dried by air, and examined with a 100X oil immersion objective [14].

### 2.3.6 Determination of Sensory attributes of the yoghurt samples

The yoghurt samples were coded and evaluated for sensory attributes by 100 individuals. Multistage selection was applied, such that various age groups, genders, occupations, and social strata were randomly chosen among students and staff of the university. A glass of water was given to each panelist so they could rinse their mouths after tasting each sample. They were also given questionnaires to score the yoghurt samples for appearance, colour, aroma, taste, consistency and overall acceptability, using a 9-point hedonic scale ranging from 0 (extremely dislike) to 9 (extremely like) [18].

## 2.4 Statistical Analysis

All analyses were performed in triplicate and presented as mean  $\pm$  standard deviation. Statistical Analysis of Variance (ANOVA) using SPSS version 28 (SPSS, Inc., USA) was applied for means variation, while the Duncan Multiple Range Test (DMRT) at an acceptable level of  $p \leq 0.05$  was utilized for the separation of means [19].

## 3. RESULTS AND DISCUSSION

### 3.1 Microbial Attributes

The physicochemical properties and microbiological loads of the yoghurt samples are presented in Table 1. Physicochemical attributes measured in this study are pH and titratable acid values, which are required to denote the acidity and possible shelf stability of the yoghurt.

**Table 1. Physicochemical and microbial count of yoghurt samples made from tiger nut milk and different forms of cow milk**

Sample	pH	Titratable Acid (%)	Total Plate Count (CFU/ml)	Lab Count (CFU/ml)
FC	4.31 $\pm$ 0.076 <sup>b</sup>	0.090 $\pm$ 0.002 <sup>a</sup>	2.123 $\times$ 10 <sup>5</sup> $\pm$ 0.035 <sup>d</sup>	1.853 $\times$ 10 <sup>5</sup> $\pm$ 0.025 <sup>d</sup>
SK	4.65 $\pm$ 0.035 <sup>d</sup>	0.088 $\pm$ 0.001 <sup>a</sup>	1.960 $\times$ 10 <sup>5</sup> $\pm$ 0.010 <sup>c</sup>	1.570 $\times$ 10 <sup>5</sup> $\pm$ 0.026 <sup>b</sup>
FL	4.36 $\pm$ 0.030 <sup>b</sup>	0.092 $\pm$ 0.003 <sup>a</sup>	1.747 $\times$ 10 <sup>5</sup> $\pm$ 0.015 <sup>b</sup>	1.092 $\times$ 10 <sup>5</sup> $\pm$ 0.028 <sup>a</sup>
TN	3.97 $\pm$ 0.017 <sup>a</sup>	0.095 $\pm$ 0.010 <sup>b</sup>	1.750 $\times$ 10 <sup>5</sup> $\pm$ 0.030 <sup>b</sup>	1.630 $\times$ 10 <sup>5</sup> $\pm$ 0.026 <sup>c</sup>
CN	4.53 $\pm$ 0.035 <sup>c</sup>	0.091 $\pm$ 0.002 <sup>a</sup>	1.361 $\times$ 10 <sup>5</sup> $\pm$ 0.029 <sup>a</sup>	1.063 $\times$ 10 <sup>5</sup> $\pm$ 0.047 <sup>a</sup>

Means in the same column with same superscript letters are not significantly different at  $p \leq 0.05$ . FC- Full cream milk yoghurt; Sk – Skim milk yoghurt; FL – Fat-filled milk yoghurt; TN – Tiger nut milk Yoghurt; CN – Commercial Yoghurt (Control), LAB – Lactic Acid Bacteria

**Table 2. Morphological and biochemical features of yoghurt samples made from tiger nut milk and different forms of milk**

Biochemical Feature	LAB 1	LAB 2	LAB 3
Shape	Coci	Rod	Rod
Cell Setting	Single/ short	Circular	Paired/ long
Texture	Dry	Moist	Wet
Colour	Creamy	Off-white	Whitish
Elevation	Flat	Irregular	Raised
Appearance	Opaque	Opaque	Shinny
Catalase	-	-	-
Oxidase	-	-	-
Coagulase	+	+	+
Gram staining	+	+	+
Probable Organism	<i>Lactobacillus acidophilus</i>	<i>Lactobacillus bulgaricus</i>	<i>Streptococcus thermophilus</i>

The microbial attributes evaluated are Total Plate Count (TPC) and Lactic Acid Bacterial (LAB) count of the yoghurt samples. This indicates the general active culture and expected probiotic loads in each sample. pH indicates the extent of acidity or alkalinity of a medium. The pH values differed significantly ( $P \leq 0.05$ ). Tiger nut milk yoghurt exhibited the significantly lowest acidic value of 3.97, while skim milk yoghurt had the highest at 4.65.

Titrateable acidity (TA) measures acid(s) quantity in a medium. The titrateable acid levels in the samples did not differ significantly, except for tiger nut milk yoghurt, which had the highest significant value of 0.95%.

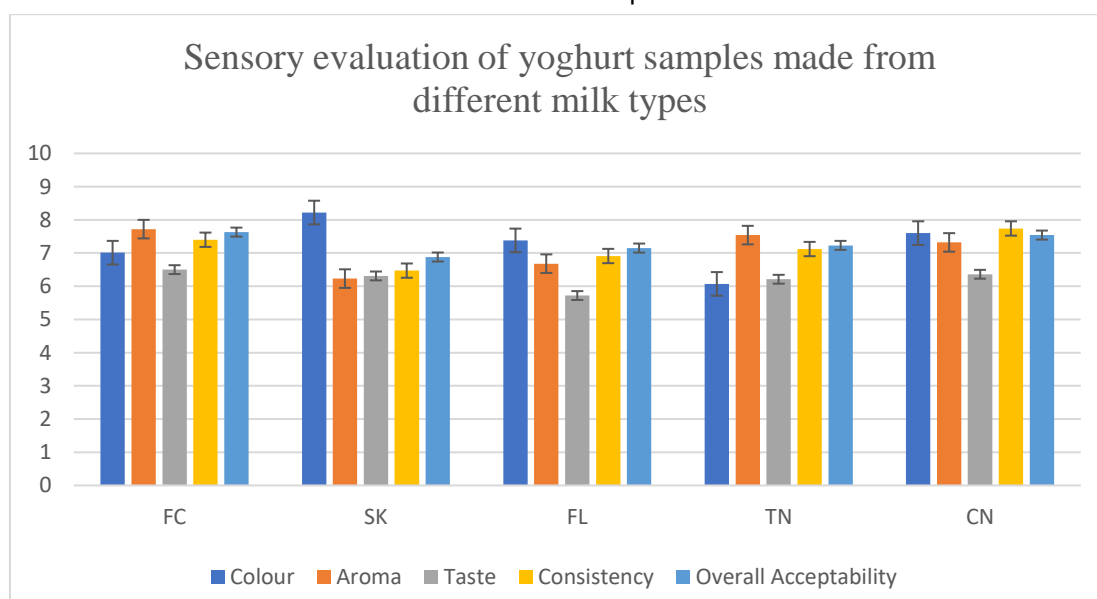
Microbiological loads, as shown in Table 1, reveal a total microbial count ranging from  $1.36 \times 10^5$  to  $2.13 \times 10^5$  CFU/ml, while lactic acid bacteria (LAB) ranged from  $1.063 \times 10^5$  to  $1.85 \times 10^5$  CFU/ml.

After determining the LAB count in the samples, it became necessary to identify these bacteria further to indicate the probable organisms in the samples. Microbial occurrences are Indigenous to fermented foods, with Lactic Acids Bacteria being more dominant in yoghurts. *Lactobacillus acidophilus*, *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, were identified as the probable organisms after morphological and biochemical tests were conducted in all the yoghurt samples.

### 3.2 Sensory Evaluation

The sensory attributes of colour, aroma, taste, consistency and overall acceptability of yoghurt samples made from tiger nut milk and different forms of cow milk are presented in Fig. 1. The sensory values for all parameters ranged from 6.07 to 8.22 for colour, 6.23 to 7.72 for aroma, 5.72 to 7.74 for consistency and 6.88 to 7.63 for overall acceptability [20].

Tiger nut milk and skim milk had the highest and lowest colour values of 6.07 and 8.22. The highest aroma score was for full cream milk yoghurt (7.72), followed by tiger nut milk yoghurt (7.54), with skim milk yoghurt scoring the lowest (6.23). Taste scores ranged from 5.72 for fat-filled milk yoghurt to 6.50 for full-cream milk yoghurt, with the control (6.36), skim milk yoghurt (6.31) and tiger nut milk yoghurt (6.21) falling in between. The control sample had the highest consistency score (7.74), followed by full cream milk (7.4) and tiger nut (7.12) yoghurts, while skim milk had the lowest (6.47). Panelists preferred full cream milk yoghurt (7.63) over others, followed by the control sample (7.54), with skim milk yoghurt being the least accepted (6.88). The familiarity of panelists with full cream milk yoghurt may explain the preference. Tiger nut milk yoghurt received a high score of 7.23 and was the third most accepted yoghurt sample.



**Fig. 1. Sensory evaluation of yoghurt samples made from tiger nut milk and different forms of cow milk**

FC- Full cream milk yoghurt; Sk – Skim milk yoghurt; FL – Fat-Filled milk yoghurt; TN – Tiger nut Yoghurt; CN – Commercial Yoghurt (Control)

#### 4. DISCUSSION

The yoghurt samples examined in this study are within the recommended pH range of 4-4.50. However, it is essential to note that the pH of the skim milk sample differs slightly from this range, measuring at 4.65. The pH values of this study were found to be comparable to a previous report [21]. This similarity is desirable because it indicates that a pH level below 4.5 may be sufficient to effectively prevent the proliferation of undesirable microorganisms, thereby extending its shelf life [11].

A progressive rise in titratable acid levels and a corresponding decrease in pH values during fermentation is expected [21]. It is recommended that TA levels fall into 0.85 - 0.95 % range, which agrees with the values obtained in this study (0.88 – 0.95 %). Similar results were obtained in studies by [3,11].

Quantification of LAB is critical in the yoghurt manufacturing process, necessitating the evaluation of LAB as a crucial factor in determining the overall microbial composition of yoghurt products. The full cream milk yoghurt had the highest significant count in both cases, while the control sample showed the lowest. The control sample may contain chemical preservatives to regulate the microbial load and extend the shelf life of the yoghurt [21]. The observed microbial counts in this study indicate a significant level of microbial load in the fermented yoghurts, which is thought to be a positive characteristic of the presence of active probiotic organisms [2]. The values found in this study are slightly lower than a previous study on yoghurt derived from public school sources [3]. This could have resulted from the operating procedures since the yoghurts in this study were produced in a laboratory adhering to strict hygiene control measures [22].

Microbial occurrences are Indigenous to fermented foods, with Lactic Acids Bacteria being more dominant in yoghurts. This is because as yoghurt fermentation progresses pH decreases and inhibits the growth of many microorganisms, while LAB dominates [1]. This indicates that tiger nut milk can serve as a good substitute for cow milk if probiotic composition is the main interest [23].

The sensory values show to what extent the yoghurt samples are accepted by consumers and the possible sensory features that call for improvement [1].

Colour is a required attribute for measuring dairy and non-dairy products of milk because white or creamy colour are universally seen as milk colour. Consequently, this unconsciously affects the extent to which milk or related products are accepted. Similar colour values were obtained from tiger nut and coconut milk, ranging from 6.2-6.8 [23]. The lower value of tiger nut milk yoghurt from this study may be due to the brownish pigments in whole tiger nuts, which were leached during milk extraction.

The aroma values support the previous studies comparing tiger nut milk yogurt with fresh cow milk and other milk forms. The observation could be attributed to the diverse array of volatile aromatic chemicals and acetaldehyde produced by microbes present in tiger nut yoghurt during the breakdown of carbohydrates, enhancing its aroma [21]. The absence of fat in the skim milk could have been a limiting factor to its aroma values.

The taste of a product determines to what extent a product appeals to the sweetness or sourness of the yoghurt [11]. Lower taste scores (4.90-5.95) were observed in this study. This observation could be because animal protein sources have improved sensory perception of mouthfeel when consuming products like yoghurt. Of which fat-filled and tiger nut milk yoghurt consists of plant-based fat.

Consistency displays the smoothness, thickness, and mouthfeel of yoghurt samples. The fat content in milk products enhances its mouthfeel and emulsifying features [11]. Consequently, skim milk with no fat content exhibited the least consistency. Although skim milk is perceived to be healthier, many consumers prefer sensory over nutritional attributes.

Overall acceptability reveals to what extent consumers like or dislike a product on a general note, considering all tested parameters [21]. Therefore, tiger nut stands a chance of being a suitable option for making yoghurt, considering its acceptability, health benefits, affordability and availability [2].

#### 5. CONCLUSION

Yoghurt made from tiger nut milk and various forms of cow milk displayed similar physicochemical, microbial and sensory characteristics. The yoghurt made from full-cream milk had the highest microbial count and sensory attributes. Additionally, tiger nut milk yoghurt exhibited favourable sensory qualities

and acceptable microbial values. These findings suggest that tiger nut milk is a viable plant-based substitute for cow milk in yoghurt production. It is advisable to explore other plant-based milk alternatives for making yoghurt instead of cow milk. This will lead to a wider range of sustainable options.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. Dhakal D, Younas T, Bhusal RP, Devkota L, Henry CJ, Dhital S. Design rules of plant-based yoghurt-mimic: Formulation, functionality, sensory profile and nutritional value. *Food Hydrocoll*; 2023. Available: <https://doi.org/10.1016/j.foodhyd.2023.108786>
2. Satir G. The effects of fermentation with water kefir grains on two varieties of tigernut (*Cyperus esculentus* L.) milk. *LWT*; 2022. Available: <https://doi.org/10.1016/j.lwt.2022.114164>
3. Chimezie GD, Gloria L, Ebere I. Microbiological load of yoghurt sold in Omoku schools, Rivers State, Nigeria. *Afr J Microbiol Res*. 2015;9(34):1960–3. Available: <https://doi.org/10.5897/ajmr2015.7556>
4. Ojuko OO, Tadese AA, Nwabu OA. Physico-chemical, sensory attributes and microbial analysis of Yoghurt made from Powder Milk and Tiger-nut milk blend. *World Sci News*. 2018;(108):111–22. Available: <https://doi.org/10.15436/2377-0619.19.1824>
5. Meybodi NM, Mortazavian AM, Arab M, Nematollahi A. Probiotic viability in yoghurt: A review of influential factors. *Int Dairy J*; 2020. Available: <https://doi.org/10.1016/j.idairyj.2020.104793>
6. Nielsen SD, Jakobsen LMA, Geiker NRW, Bertram HC. Chemically acidified, live and heat-inactivated fermented dairy yoghurt show distinct bioactive peptides, free amino acids and small compounds profiles. *Food Chem*; 2021. Available: <https://doi.org/10.1016/j.foodchem.2021.131919>
7. Kielbasa A, Monedeiro F, Bernatowicz-Łojko U, Sinkiewicz-Darol E, Buszewski B, Gadzała-Kopciuch R. The content of selected omega-3 free fatty acids in breast milk samples and their interactions with macronutrients as well as personal characteristics of mothers. *Int Dairy J*. 2024;148:105803. Available: <https://doi.org/10.1016/j.idairyj.2023.105803>
8. Hafiizha A, Kayaputri IL, Tensiska T, Amalia NR. The effect of skim milk concentration on sensory quality and PH of probiotic yoghurt added with red dragon fruit (*Hylocereus polyrhizus*). *J Ilmu Teknol Hasil Ternak*. 2020;15(1):52–60. Available: <https://doi.org/10.21776/ub.jitek.2020.015.01.7>
9. Schmidmeier C, O’Gorman C, Drapala KP, Waldron DS, O’Mahony JA. Elucidation of factors responsible for formation of white flecks in reconstituted fat filled milk powders. *Colloids Surf A Physicochem Eng Asp*. 2019;575:245–55. Available: <https://doi.org/10.1016/j.colsurfa.2019.03.034>
10. Assocle MS, Okidi L, Ongeng D. The effect of rosemary, ginger, or garlic on microbial shelf life and sensory acceptability of nutritionally enriched cassava-based pancake (*Kabalagala*). *Appl Food Res*. 2024;4(1):100384. Available: <https://doi.org/10.1016/j.afres.2023.100384>
11. Odejebi OJ, Olawoye B, Ogundipe OR. Modelling and optimisation of yoghurt production from tigernut (*Cyperus esculentus* L.) using Response Surface Methodology (RSM). *Asian Food Sci J*. 2018;4(3):1–12. Available: <https://doi.org/10.9734/afsj/2018/44137>
12. Oladipo IC, Atolagbe OO, Adetiba TM. Nutritional evaluation and microbiological analysis of yoghurt produced from full cream milk, tiger-nut milk, skimmed milk and fresh cow milk. *Pensee*. 2014;76(4):30–8.

- Available:<https://doi.org/10.19080/aibm.2016.01.555573>
13. Ezeonu CS, Tatah VS, Nwokwu CD, Jackson SM. Quantification of physicochemical components in yoghurts from coconut, tiger nut and fresh cow milk. *Adv Biotechnol Microbiol.* 2016;1(5):555573. Available:<https://doi.org/10.19080/aibm.2016.01.555573>
  14. Taiwo OS, Afolabi RO, Oranusi SU, Owolabi JB, Oloyede AR, Isibor PO, et al. Microbiological assessment of commercial yogurt sold in Ota Metropolis, Ogun State, Nigeria. *IOP Conf Ser Earth Environ Sci.* 2018;012019. Available:<https://doi.org/10.1088/1755-1315/210/1/012019>
  15. De S, Pramanik A, Das AKR, Paul S, Jana S, Pramanik P. Isolation and characterization of *Lactobacillus spp.* from curd and its pharmacological application in probiotic chocolate. *J Phytopharmacol.* 2017;6(6):335–9. Available:<https://doi.org/10.31254/phyto.2017.6605>
  16. Amanullah SM, Kabir MA, Rahman MM, Halder P, Hossain SMJ, Samad MA. Isolation, identification and biochemical characterization of lactic acid bacteria from selected yogurt samples. *Bangladesh J Livest Res.* 2020;64–72. Available:<https://doi.org/10.3329/bjlr.v27i1.55170>
  17. Ngene AC, Onwuakor CE, Aguiyi JC, Ifeanyi VO, Ohaegbu CG, Okwuchukwu CP, et al. Screening of some lactic acid bacteria isolated from selected Nigerian fermented foods for vitamin production. *Adv Microbiol.* 2019;9(11):943–55. Available:<https://doi.org/10.4236/aim.2019.911060>
  18. Chinma CE, Adedeji OE, Etim II, Aniaka GI, Mathew EO, Ekeh UB, et al. Physicochemical, nutritional, and sensory properties of chips produced from germinated African yam bean (*Sphenostylis stenocarpa*). *LWT.* 2021; 136:110330. Available:<https://doi.org/10.1016/j.lwt.2020.110330>
  19. Ojukwu M, Ofoedu C, Seow EK, Easa AM. Optimization of soy protein isolate, microbial transglutaminase and glucono- $\delta$ -lactone in gluten-free rice noodles. *J Sci Food Agric.* 2021;101(9):3732–41. Available:<https://doi.org/10.1111/ijfs.15491/v1/review4>
  20. Makut MD, Olokun AL, Olokun RM. Production of yoghurt from milk extract of tigernut (*Cyperus esculentus*) using lactic acid bacteria isolated from locally fermented milk (nono). *Asian Food Sci J.* 2018;4(1):1–8. Available:<https://doi.org/10.9734/afsj/2018/42984>
  21. Maduka N, Ire FS. Tigernut plant and useful application of tigernut tubers (*Cyperus esculentus*)—A review. *Curr J Appl Sci Technol.* 2018;29(3):1–23. Available:<https://doi.org/10.9734/cjast/2018/43551>
  22. Bristone C, Badau MH, Igwebuike JU, Igwegbe AO. Production and evaluation of yoghurt from mixtures of cow milk, milk extract from soybean and tiger nut. *World J Dairy Food Sci.* 2015;10(2):159–69. DOI:[org/10.5829/idosi.wjdfs.2015.10.2.94216](https://doi.org/10.5829/idosi.wjdfs.2015.10.2.94216)
  23. Anumba N, Joy E-E, Ishiwu C, Wabali V. Physicochemical properties and sensory evaluation of a plant-based yoghurt produced from blends of tiger nut, coconut and dates. *World J Food Sci Technol;* 2023. Available:<https://doi.org/10.11648/j.wjfst.20230703.12>

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

© Copyright (2024): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:  
The peer review history for this paper can be accessed here:  
<https://www.sdiarticle5.com/review-history/122226>